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Ethnobotanical survey of the medicinal plants used in Kakamega County, western Kenya

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ABSTRACT

Aim: This study was carried out to identify the medicinal plants used by the Luhya community in Kakamega County and promote the preservation of this traditional knowledge.
Methods: An ethnobotanical study was carried out between March 2016 and April 2016. Information from the 26 participants was obtained through face-to-face interviews, field observations, and by the use of semi-structured questionnaires. A literature review was done to identify the previously reported traditional uses and pharmacological activities. The relative frequency of citation, use values, and fidelity level values of the reported medicinal plants were calculated.
Results: A total of 94 plants from 41 botanical families were reported to be used as medicinal plants. Nearly 25.5% of the plants were from the Asteraceae and Fabaceae families and the plant parts commonly used were leaves (48%) and roots (29%). The herbal remedies were prepared mainly (65%) as decoctions while the preferred (80%) route of administration was oral. Nearly 25 medicinal plant species were reported for the first time in Kakamega County. Remedies for malaria, stomach aches, skin diseases, and backache were frequently sought.
Conclusion: The ethnobotanical and pharmacological literature reviewed justify the use of these 94 species in traditional medicine for both the prevention and treatment of diseases.

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Introduction

Access to conventional healthcare is a challenge in Kenya, especially in rural areas. This is because resources are usually concentrated in urban areas leaving few doctors working in rural areas. Whereas the WHO recommends a doctor-patient ratio of 1:1,000, the situation in Kakamega County is 1:14,246 [1]. Such challenges in the Kenyan public health sector have resulted in an upsurge in the use of plant-based remedies [2]. Traditional medicine is generally perceived to be more accessible and affordable with the practices being diverse and based on cultural and geographical lines. Usually, various communities from the different regions of the country have distinct traditional medicine practices. For example, an ethnobotanical survey in Kit Mikayi Region, Western Kenya revealed that the similar plants used in folk medicine were valued differently across various locations in western Kenya [3,4].

Traditional knowledge is passed orally from one generation to the next posing a risk of its loss. Furthermore, the traditional knowledge from the 42 Kenyan ethnic communities largely remains untapped since the literature on Kenyan medicinal plants is quite scarce as very few documented reports on this information exist [5,6]. Therefore, there is a need to document it for future reference and research on Kenyan medicinal plants. Currently, various initiatives to promote research and documentation of traditional medicine and natural products in Kenya are being implemented. They include the establishment of the Traditional Medicine and Drug Development Programme at the Kenya Medical Research Institute in 2011, training on complementary and alternative medicine at various institutions

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of higher learning and the registration of locally produced natural products by the regulatory body Pharmacy and Poisons Board [6–9].

Kakamega County is a region famed for its biodiversity and widespread use of the medicinal plants. Ethnobotanical surveys are effective in preserving traditional knowledge through proper documentation of plants used and also encourage the sustainable use of the medicinal plants alongside creating a database for research into medicinal plants that may have clinically useful potential. For instance, through records of the Chinese traditional medicines, the wormwood (*Artemesia annua*) proved to be a valuable lead in the fight against malaria [10]. Locally, the Naturub® ointment was developed from purified *Ocimum kilimandscharicum* Guerke extracts based on its traditional use [6]. The ethnobotanical knowledge from Western Kenya largely remains unknown and is likely to be rich and worth documenting. Therefore, there is a need for more extensive excursions into the Kakamega forest and its environs in order to reveal and preserve information on medicinal plant species [2,9]. This study sought to identify medicinal plants used in Kakamega County.

Materials and Methods

Study area

The study was carried out between March 2016 and April 2016 in Kakamega County which is located in the western part of Kenya about 30 km north of the equator. The climate is tropical, high rainfall is often experienced and the major economic activities are farming and fishing [11]. Kakamega County is a largely rural area, has a total area of 3,050.3 km^2 and is the second largest County in Kenya with a population of 1,660,651. The County has a total of 55 health facilities (12 hospitals, 15 health centers, 20 dispensaries, and 8 clinics) [1]. Kakamega County has 12 constituencies and is largely inhabited by the luhya community composed of 18 sub-tribes. The luhya tribe "*abaluhya*" is a Bantu speaking community with a rich culture that is evident in their cuisine, music, and sports (cock and bullfighting) [12].

Kakamega County is home to Kakamega forest reserve which is a tropical rainforest with high species richness located about 35 km from Lake Victoria. The forest covers about 230 km^2, and currently, less than 50% is an indigenous forest. It has a variety of unique flora and fauna and almost 10%–20% are unique animal species. There are around 160 trees and shrub species [13]. The forest is very useful to the local communities as a source of timber, fuel, traditional medicines food, and various cultural activities [14].

Study approval

Ethical approval for this study was obtained from Kenyatta National Hospital, University of Nairobi Research Ethics Review Committee (Reference number: P38/1/2016). Prior to conducting the interviews, the objectives of the study were well explained to the study participants and written consent obtained.

Ethnomedicinal data collection

This study was conducted in seven constituencies in Kakamega County. Local leaders (chiefs and village elders) well versed with the local environment and indigenous language facilitated contact with reputable traditional medicine practitioners (TMPs) and villagers who had knowledge on traditional medicine and with whom interviews were carried out. Purposive sampling and snowballing methods were used to recruit participants [15]. To participate in the study, participants had to possess knowledge on traditional medicine, be at least 18 years, have lived in Kakamega County for a period not less than 3 years and had an understanding of the local area and local names of plants. The initial participants recruited assisted to identify other willing participants through their existing networks [9]. A minimum of 12 participants was recommended for this kind of qualitative studies. Saturation was reached when the collection of new data did not yield any new information on the medicinal plants used [16,17].

The face-to-face interviews were conducted in the native language of the participants, luhya and the Kenyan national language, Kiswahili, depending on the participants' preference. Semi-structured questionnaires were used for data collection. The information collected included the age and gender of participants, source of traditional knowledge, local names of the plant(s) and part(s) used, ailment treated, methods of preparation and administration, and use of conventional medicines.

After the interviews, plants listed by the study participants were collected from their natural habitat and voucher specimens deposited at the University of Nairobi, School of Biological Sciences Herbarium.

Quantitative analysis

The frequency of citation (FC) for each of the reported plant species was used as a basis to identify popularly used plants in the study area. Relative frequency citation (RFC) was obtained by dividing the number of informants mentioning a useful species (FC), by the total number of informants in the survey (*N*). RFC value varies from 0 (when nobody refers to a plant as a useful one) to 1 (when all the informants mentioning it as useful).Use value (UV) of the reported species was assessed using the expression; UV = ΣU/*n*, where *U* is the number of user citation and *n* is the number of the respondents. The UV demonstrates the relative importance of plants known locally.Fidelity level (FL) was calculated using the expression, FL_{ij} (%) = $NP_{ij}/N_i \times 100$, where NP_{ij} is the number of use-reports cited for a given plant species; *i* for a particular ailment category *j* and N_i is the total number of use-reports cited for any given species *i*. FL shows the most useful species used for a particular health condition [18].

Results and Discussion

Socio-demographic characteristics of participants

The study had 26 participants. Six of them were male (23%) and 20 were female (77%). Their age ranged from 35 to 87 years with 38% of the participants aged between 35 and 50 years, 47% aged between 50 and 65 years, while 15% were 65 years and above. Nearly 45% of the participants had completed primary level education. Nearly 54% of the participants indicated that they had acquired their knowledge on traditional medicine from close relatives, 34% had learnt the skill from a practicing TMP, 8% from literature, and 4% from dreams/divine call.

The absence of cultural restrictions on gender in the practice of traditional medicine within this community may be the reason for more female (20) participants than the male (6) participants. The family institution plays a major role in the preservation of traditional knowledge as more than half (54%) of the participants reported close relatives as being their source of traditional knowledge.

Medicinal plants, their applications, preparation methods, and route of administration

A total of 94 species from 41 families were encountered during the survey (Table 1). The most represented families were Asteraceae (13.8%) and Fabaceae (11.7%). Thirty-eight illnesses recorded were grouped into 13 categories of which malaria, stomach aches and other digestive related diseases, skin diseases, backache, and sexually transmitted infections featured prominently. Others include inflammation, respiratory diseases, oral and ear infections, diabetes, high blood pressure, reproductive diseases, and general wellbeing. Western Kenya is a malaria epidemic region with a tropical forest, high poverty levels (57%), and reports of drug resistance [19,20]. This may explain the use of plants such as *Melia azedarach* L., *Justicia betonica* L., and *Aloe* spp. in the management of malaria during this study. These findings concur with those of Mukungu et al. [20] whereby these three plants were reportedly used to treat malaria in western Kenya. The need for backache remedies could be precipitated by the presence of the elderly within the rural population who commonly experience backaches and also economic activities such as farming from which back pain may result. Stomach aches, other digestive related diseases, and skin diseases may be attributed to the high poverty levels and poor sanitation as reported in similar studies [2].

The plant parts commonly used were leaves (48%) followed by roots (29%) and stem bark (19%). For small herbaceous plants such as *J. betonica* L. and *Cuscuta australis* R. Br., the whole plant was used. Leaves were preferred as they were perceived to be an easily renewable source. This concurs with the findings earlier reported around Kakamega forest that the predominant use of leaves is because their harvesting methods were less destructive than roots and barks; thus, promoting conservation of medicinal plants [2]. For 50% of the reported plants, different parts (mainly leaves, barks, and roots) of the same plant were utilized for the medicinal purpose. This may be due to the ease of harvesting or the potency of the different plant parts. For example, the leaves and barks of *M. azedarach* L. were used as a remedy for Malaria. Often, phytochemicals are variably distributed in tissues and *M. azedarach* L. has been shown to contain bioactives in both the barks and leaves [21].

Most (65%) of the plants were prepared as decoctions (possibly the actives are heat stable) and 32% as poultices with most plants being used in combination (concoctions). For example, a concoction reported during the study was prepared by boiling the stem barks of *Mangifera indica* L. and *Persea americana* Mill. with the roots of *Carica papaya* L. and taken orally to remedy syphilis. These plants have been proven to possess antimicrobial activity [22–24], thus the remedy had a synergistic

Table 1. Medicinal plants used in Kakamega County.

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Abrus precatorius L. (Fabaceae) EAO2016/001	Olubinu	Inflamed breasts in breast-feeding mothers (1), family planning (2), coughs (1)	WP	Burned to ash, oral	Coughs, oral contraceptive, painful swelling, and expectorant [40]	4	0.15	0.12	50
Acacia sp (Fabaceae) EAO2016/002	Eshisisia	Boils (2)	L	Crushed/boiled, topical	Gonorrhea, skin disorders [41]	2	0.08	0.08	100
Acanthus eminens C. B. Clarke (Acanthaceae) EAO2016/003	Lirakhalu	High blood pressure (1) stomach aches (1)	L, Rt	Boiled, oral	Antimalarial, stomachaches, and constipation [41,42]	1	0.04	0.08	100
Acmella caulirhiza Delile (Asteraceae) EAO2016/004		Coughs (1), mouth ulcers (1), diarrhea (2)	L	Boiled, oral	Analgesic, chest complaints, and mouth sores [43,44]	2	0.08	0.12	100
Ageratum conyzoides Linn. (Asteraceae) EAO2016/005	Liliviri/Ikhore	Stops bleeding after injury (1), stomach aches (1), bloody diarrhea (1)	L, Rt	Crushed/boiled, topical	Wounds and burns [45], anti-dysenteric, stomach aches, and cough [26].	1	0.04	0.12	100
Albizia gummifera (J. F. Gmel.) (Fabaceae) EAO2016/006	Omushenzeri	Skin disease (2), coughs (1) flu (1) malaria (2)	B, S	Boiled, oral	STI, skin cancer, fever, and headaches [8]	2	0.08	0.23	100
Aloe sp (Xanthor rhoeaceae) EAO2016/007	Eshikaha	Malaria (6), diabetes (2), nausea (1), blood cleanser (2), acne (1)	L	Boiled, oral	Appetizer, malaria, skin diseases, wounds, and blood purifier [8]	8	0.31	0.46	75
Alternanthera sessilis L. (Amaranthaceae) EAO2016/008		Eye infections (1), wounds (1), skin diseases (1)	L	Eye drops/ crushed, topical	skin diseases, severe pain [28]	1	0.04	0.12	100
Asparagus setaceus (Willd.) (Asparagaceae) EAO2016/009		Tooth aches (1)	Rt	Crushed, oral	Pneumonia, Coughs, bilharzia [40]	1	0.04	0.04	100

Continued

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Aspilia pluriseta Schweinf. (Asteraceae) EAO2016/010	Shilamalama	Wound healing (3), skin diseases (1), liver damage (1)	L	crushed/boiled	Skin disease, eye problems, and wounds [8,40]	5	0.19	0.19	60
Bridelia micrantha Baill. (Euphorbiaceae) EAO2016/011	Omunyeren yere/eshikan gania/litumusi	Dysentery (1) Skin diseases (1) allergy (1) stomach ache (2)	L, B, Rt	Boiled/crushed, oral/topical	Purgative, Stomach ache [27]	2	0.08	0.19	100
Caelsalpinia volkensii Harms (Caesalpiniaceae) EAO2016/012	Omuchera (ajua)	Headaches (1), joints (1), malaria (1)	L, Rt	Boiled, oral	Malaria [29]	3	0.12	0.12	33
Cajanus cajan (L.) Millsp. (Fabaceae) EAO2016/013	Ing'oring'ori	Severe flu (1), constipation (1), weight loss (1)	L	Boiled, oral	Wounds, diarrhea, diabetes, laxative, and dysentery [46]	1	0.04	0.12	100
Capsicum frute scens L. (Solanaceae) EAO2016/014	Pilepile	Joints (1)	F	Crushed/boiled, oral	Throat problems, rheumatism, arthritis, and muscular pains [8]	1	0.04	0.04	100
Carica papaya L. (Caricaceae) EAO2016/015	Lipapai	STIs (2), worms (1)	Rt, F	Boiled, oral	Anthelmintic, gonorrhea, and urinary tract infection [8,47]	3	0.12	0.12	67
Carisa spinarum L. (Apocynaceae) EAO2016/016	Eshikata	Eye infections (2), anthelmintic (1), reduces body fat (1)	Rt	Boiled/crushed, oral/topical	Liver disease, microbial disease [48]	3	0.12	0.15	67
Centella asiatica L. (Apiaceae) EAO2016/017	Neruielala	Tooth ache (1), Ear infections (1)	L, Rt	Crushed, apply on tooth/ear drop	Fever, jaundice, inflammation, fever, and analgesic [8]	2	0.08	0.08	100
Chenopodium opulifolium Schrad. ex W. D. J. Koch and ZizDC. (Chenopodiaceae) EAO2016/018	Olukhosha koshe	Diarrhea (1), fever in babies (1)	L, Rt	Boiled, oral	Wound, malaria [49]	1	0.04	0.08	100
Clerodendrum myricoides Hochst. (Lamiaceae) EAO2016/019	Eshirangokho	Eye infections (3)	L	Boiled, oral	Malaria, chest pains, rheumatism, gonorrhea, and wounds [8]	3	0.12	0.12	100

Continued

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Combretum apiculatum Sond (Combretaceae) EAO2016/020	Muhungula/ chisala	Gonorrhea (1), Skin diseases (1), stops bloody urine (1)	Rt, B	Boiled, oral	Conjunctivitis, stomach disorders, and acne [50]	1	0.04	0.12	100
Combretum molle R.Br. ex G. Don (Combretaceae) EAO2016/021	Muhungula	Gonorrhea (1), Snake bites (1)	B, Rt	Boiled, oral	Anthelmintic, coughs, fever, stomach ailments, and wounds [50]	2	0.08	0.08	50
Conyza sumatre nsis (Retz.) E. H Walker (Astera ceae) EAO2016/022	Nyangweso/liposhe	Malaria (6) appetizer (1), tonsils (1), skin pimples (1) throat infections (2)	L	Crushed, oral	Malaria [31]	9	0.35	0.42	67
Corchorus olitorius L. (Malvaceae) EAO2016/023	Omurere	Vegetable (3), Teething in babies (1)	L	Crushed/boiled, oral	Toothaches, sore throat, vomiting, strong bones and teeth, laxative [41]	3	0.12	0.15	100
Cordia africana Lam. (Boraginaceae) EAO2016/024	Omukamari	Bone injuries (5)	S, B	Boiled, topical	Broken bones, venereal diseases [41]	5	0.19	0.19	100
Crotalaria anagyroides Kunth. (Fabaceae) EAO2016/025	Musala kwe ingombe	Cow feed (1)	L	Oral	Fodder [51]	1	0.04	0.04	100
Crotolaria pallida Aiton. Hort. (Fabaceae) EAO2016/026		Oral infections (2)	Rt	Chewed, oral	Skin diseases [52]	2	0.08	0.08	100
Croton macrostachyus Delile (Euphorb iaceae) EAO2016/027	Omusutsu	Asthma (1), bleeding wounds (3)	B, L, Rt	Boiled/crushed, oral/topical	Coughs, purgative, and wound healing [8]	3	0.12	0.15	100
Cucumis figarei Naud. (Cucurbitaceae) EAO2016/028	Eshirange tsatsa	Malaria (2)	L	Boiled, oral	Toothache [53]	2	0.08	0.08	100
Cuscuta australis R. Br. (Convolvulaceae) EAO2016/029	Yaambimbi	Typhoid (1), diarrhea (2)	WP	Crushed add water, oral	laxative, anthe lmintic, sores me asles kidney and liver diseases, eye diseases [41]	3	0.12	0.12	67

Continued

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Cymbopogon citratus (DC.) (Poaceae) EAO2016/030	Majani kho bulimo	Flu/colds (4)	L	Boiled, oral/inhale	Calmant, gastrointestinal disorders, colic treatment, anxiety, and aromatherapy [54]	4	0.15	0.15	100
Cyphostemma ukerewense (Gilg) Desc. (Vitaceae) EAO2016/031	Libombola	Tonsils (1)	L	Crushed, oral	Abscess with maggots [55]	1	0.04	0.04	100
Dichrocephala integrifolia (L.f.) O. Kuntze (Asteraceae) EAO2016/032		Oral infection (2), diarrhea (1)	L	Crushed add water, oral	Dental infection, tooth extraction [56]	2	0.08	0.12	100
Dicliptera laxata C. B. Clarke (Acanthaceae) EAO2016/033	Lunyasi-lwibituti	Diarrhea (1), skin rashes (1)	Rt, L	Chewed/boiled, oral	Rashes and itching [57]	1	0.04	0.08	100
Dovyalis macrocalyx Warb. (*Salicaceae*) EAO2016/034	Shina-muterwa/ likunga	Boils (2)	L, Rt	Crush, oral	Headache, constipation, ulcers [2]	2	0.08	0.08	100
Dyschoriste radicans (Hochst. ex A. Rich.) (Acanthaceae) EAO2016/035	Esimenenenwa	Itchy skin (3)	L	Crushed, topical	Stomach aches [58]	3	0.12	0.12	100
Eriobotrya japonica (Thumb) (Rosaceae) EAO2016/036	Iqogat	Diabetes (2), Food (3)	F, B	Chewed/boiled, oral	Cough, asthma, chronic bronchitis, phlegm, high fever and gastro-enteric disorders [54]	3	0.12	0.19	67
Erythrina abyssinica Lam. ex DC (Fabaceae) EAO2016/037	Omurembe	Body swellings (2), chest problems (1) blood cleanser (1)	B, Rt	Boiled, oral	Mumps, cramps, abdominal distension, fever, coughs, and liver inflammation [41]	2	0.08	0.15	100
Euphorbia hirta L. (Euphorbiaceae) EAO2016/038	Okwambere	Asthma (3)	L	Boiled, oral	Gastro-enteric disorders, bronchial and respiratory disorders [59]	3	0.12	0.12	100

Continued

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Flueggea virosa Voigt. (Phyllanthaceae) EAO2016/039	Olusasari	Chest problems (5), headaches (2), AIDS management (3)	L, Rt	Crushed/boiled, oral	Contraceptive, pneumonia [60]	10	0.39	0.38	50
Fuerstia africana T. C. E. Fr.(Lamiaceae) EAO2016/040	Omwonyo/ Kwa matsai	Oral infections (4)	L	Boiled, oral	Tooth aches, eye [61]	4	0.15	0.15	100
Harungana madagscariensis Lam. ex poir (Hypericaceae) EAO2016/041	Omusira/ munamasai	Stomach aches (1), itchy genitals (1), Diarrhea (2)	B	Boiled, oral	Headache, Malaria, Diarrhea, and gonorrhea [41]	4	0.15	0.15	50
Hibiscus fuscus Garcke (Malvacea) EAO2016/042	oluvu	Stroke (1), chest problems (2)	L, Rt	Crushed add cold water, oral	Muscle pull [49]	3	0.12	0.12	67
Hyptis pectinata L. (Lamiaceae) EAO2016/043	Liliviri/ Lifumire likari	Stomach aches (2)	L, Rt	Crushed/boiled, oral	Throat and skin inflammations, pain, and cancer [62]	2	0.08	0.08	100
Ipomea cairica L. (Convolvulaceae) EAO2016/044	Olunyiri	Colds (1), measles (1)	L	Boiled, oral	Rheumatism, inflammations [63]	1	0.04	0.08	100
Jatropa podagrica (Euphorbiaceae) EAO2016/045	Amanyasi	Chest problems (1), fever (1)	L	Boiled, oral	Skin infections [64]	2	0.08	0.08	100
Justicia betonica Linn. (Acanthaceae) EAO2016/046	Shikuduli/ amanyasi	Tooth aches (2)	WP	Chewed, oral	Malaria, inflammation, and muscular pains [65,66]	2	0.08	0.08	100
Kalanchoe densiflora Rolfe (Crassulaceae) EAO2016/047	Okwamatsi	General well-being (1)	L	Boiled, oral	Injuries, wounds, anticancer, and swelling on skin [67]	1	0.04	0.04	100
Lantana camara L. (Verbenaceae) EAO2016/048	Ilantana	Nose bleeding (1), breathing problems (1)	L	Crushed, topical	Coughs, sore throat, conjuvictis, toothache, colds inhalant, and respiratory diseases [41,54]	1	0.04	0.08	100
Lantana trifolia L. (Verbenaceae) EAO2016/049	Shimenenwa shi imbuli	Hiccups (1), chest problems (2), eye injury (1)	L, Rt	boiled/Chew and blow air to injured eye, oral/eye drops	Coughs hepatic disease, and chewing sticks [8]	3	0.12	0.15	67

Continued

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Mangifera indica L. (Anacardiaceae) EAO2016/050	Liembe	STIs (2), Food (2)	B, L, F	Boiled, oral	Gastro intestinal tract disorders, diarrhea, and sore throat [68]	2	0.08	0.15	100
Markhamia lutea (Benth) K. Schum. (Bignoniaceae) EAO2016/051	Olusiola	Malaria (7), eye problems (3), STIs (4)	L, B, Rt	Boiled, oral	Malaria, Syphilis, wounds, and conjunctivitis [41]	12	0.46	0.54	58
Maytenus arbutifolia var. sidamoensis (Celastraceae) EAO2016/052	Omukunga	Wound healing (1)	L	Crushed, topical	Livestock feed [41]	1	0.04	0.04	100
Melia azedarach L. (Meliaceae) EAO2016/053	Mwarubaine	Malaria (2), Blood cleanser (1), skin diseases (3), stomach aches (1), headaches (1)	L, B, Rt	Boiled, oral/ topical	Stomach aches, measles, malaria, and body pains [8]	5	0.19	0.35	60
Microglossa pyrifolia (Lam.) Kuntze (Asteraceae) EAO2016/054	Ingwe	Expel placenta (1), Joints (1), wound healing (2)	Rt, L, S	chewed Crushed/ boiled, oral/ topical	Headaches, Colds, Malaria, emetic, and fever [41]	3	0.12	0.15	67
Ocimum gratissimum L. (Lamiaceae) EAO2016/055	Omwonyo	Stomach ulcers (1), Throat infections (2) Bloody diarrhea (1)	L	Boiled, oral	Constipation [69]	2	0.08	0.15	100
Persea americana Mill. (Lauraceae) EAO2016/056	Liovacado	STIs (2), Tooth ache (1)	B, L, S	boiled/crushed, oral	Hypertension [70]	2	0.08	0.12	100
Phyllanthus fischeri Pax (Euphorbiaceae) EAO2016/057	Olukhala	Skin diseases (2)	L, Rt	Crushed/boiled, topical	General body illness, AIDS management, skin cancer [1,41]	2	0.08	0.08	100
Physalis minima L. (Solanaceae) EAO2016/058	Akhalwa katitii	Boils (1)	L	Crushed, oral	Inflammations, enlarged spleen [71]	1	0.04	0.04	100
Physalis peruviana L. (Solanaceae) EAO2016/059		Chest problems (2)	F, L	Boiled, oral	Asthma, malaria and dermatitis [72]	2	0.08	0.08	100
Pittosporum mannii Hook. F. (Pittosporaceae) EAO2016/060	Mmonyo	Measles (1), Oral infections (2), fever (1),	L, B	Boiled, oral	Malaria, fever, and stomach ache [73]	4	0.15	0.15	50

Continued

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Plectranthus barbatus Andrews (Lamiaceae) EAO2016/061	Eshirookha	Chest problems (6), skin diseases (6), malaria (4)	L, Rt	Boiled, oral	Stomach ache, Fever, wounds, sores, and respiratory conditions [74]	16	0.6	0.54	75
Psidium guajava L. (Myrtaceae) EAO2016/062	Lipera	STIs (2), food (3), nausea (3), diarrhoea (1)	B, Rt, F	Boiled, oral	Food, wounds, pain relief, and fever [75]	3	0.12	0.35	100
Rhus vulgaris Meikle (Anacardiaceae) EAO2016/063	Omusangula	Coughs (2), colds (2), abdominal pains(1), gonorrhea (1)	L, S, Rt, B	Boiled, oral	Sexual impotence and erectile dysfunction [76]	5	0.19	0.23	40
Ricinus communis L. (Euphobiciae) EAO2016/064	Libono	Skin diseases (2), snake bites (1), induce labor (2), family planning (4)	Rt, L	Boiled/Chewed, oral/topical	Expel placenta and hasten parturition, wound healing [8]	7	0.23	0.35	57
Rosmarinus officinalis L. (Labiatae) EAO2016/065	Rosemary	Flu (4)	L	Boiled, oral/ inhaled	Flavoring food, tonic, boils and wounds, expectorant [77]	4	0.15	0.15	100
Rubia cordifolia L. (Rubiaceae) EAO2016/066	Oluanda nguvo	Coughs (1), Ringworms (1), oral infections (2)	L, S, Rt	Burned, oral	Skin disorders, wound healing [78]	4	0.15	0.15	50
Rumex abyssinicus Jacq (Polygonaceae) EAO2016/067	Amanyasi	Eye infections (2), general wellbeing (1)	L	Eye drops/boiled, oral	Pneumonia, coughs, stomachache, and wound healing [41]	3	0.12	0.12	67
Rumex usambarensis (Eng. ex Damm.) (Polygonaceae) EAO2016/068	Likaachi	Urinary tract infections (1)	L, Rt	Boiled, oral	Peptic ulcers, diarrhea, and vomiting [79]	1	0.04	0.04	100
Sapium ellipticum Hochst. ex Krauss (Euphorbiaceae) EAO2016/069	Omuthese	Asthma (2)	B, Rt	Boiled, oral	Coughs [41]	2	0.08	0.08	100
Senna didmobotrya (Fresen.) Irwin and Barneby (Fabaceae) EAO2016/070	Olubino	Stomach aches (1)	L, S, Rt	Burned/boiled, oral	Malaria, Headaches, and back aches [8]	1	0.04	0.04	100
Senna occindentalis L. (Fabaceae) EAO2016/071		Coughs (2)	Rt	Boiled, oral	Asthma, coughs, inflammation, and malaria [8]	2	0.08	0.08	100
Sesbania sesban (L.) Merr. (Fabaceae) EAO2016/072	Olukhure	Genital infections (2), constipation (1)	L, B	Crushed add water/boiled, topical/oral	Purgative, analgesic, and inflammation [80]	3	0.12	0.12	67

Continued

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Sida cordifolia L. (Malvaceae) EAO2016/073	Olulundu	Family planning (1)	Rt, L	Crushed and boiled, oral	Stimulate menstruation, abortifacient, diarrhea, and lumbago (muscle and joints pain) [41]	1	0.04	0.04	100
Sida tenuicarpa Vollesen (Malvac eae) EAO2016/074	Eshukutuli	Boils (1), Wound healing (1)	L, Rt	Crushed/chewed, oral/topical	Expel placenta, sore throat [41]	1	0.04	0.08	100
Solanecio cydonifolius (O. Hoffm.) C. Jeffrey (Asteraceae) EAO2016/075	Omwikhalu	Joint pains (1)	L	Crushed, oral		1	0.04	0.04	100
Solanecio mannii (Hook. f) C. Jeffrey (Asteraceae) EAO2016/076	Likaara/ livokho	Skin diseases (2)	L, Rt	Boiled/crushed, oral/topical	Skin cancer [1]	2	0.08	0.08	100
Solanum dasyphylum Schumach. (Solanaceae) EAO2016/077	Indula	Induce labor (2), back aches (1)	Rt, L	Boiled, oral	Trypanosomiasis, cough [81]	2	0.08	0.12	100
Solanum incanum L. (Solanaceae) EAO2016/078	Indulandula	Stomach aches (2), diarrhea (1)	Rt, L	Chewed/boiled, oral	Toothache, stomach aches, and indigestion [8]	4	0.15	0.12	50
Spathodea campanulata Beauv. (Bignoniaceae) EAO2016/079	Omutirisya	Tongue infections (5)	L	Crushed, oral	Malaria, bacterial infections, and respiratory diseases [82]	5	0.19	0.19	100
Spermacoce princeae (K. Schum.) Verdc. (Rubiaceae) EAO2016/080	Kisunda shikuu	Boils (1)	L, Rt	Boiled, oral	Skin diseases, hepatic disease, and bacterial infections [41]	1	0.04	0.04	100
Stephania abyssinica (Dillon. and A. Rich.) Walp. (Meni spermaceae) EAO2016/081	Omulandala	Heart problems (1), gonorrhea (1)	L, Rt	Crushed, oral	HIV [83]	2	0.08	0.08	50
Syzygium guineense DC. (Myrtaceae) EAO2016/082	Omusioma	Menstrual pain (1)	B	Boiled, oral	Abdominal pains/ stomach aches [8]	1	0.04	0.04	100

Continued

Botanical name, family and voucher no.	Local name	Ailments treated and frequency	Part used	Method of preparation and adminis tration	Previously reported traditional use	Quantitative analysis			
						FC	RFC	UV	FL
Tagetes minuta L. (Asteraceae) EAO2016/083	Inzakha	Skin diseases (2)	L	Boiled, steam bathing	Condiment, colds, and respiratory tract inflammations [84]	2	0.08	0.08	100
Tarenna graveolens (S. Moore) Bremek. (Rubiaceae) EAO2016/084	Oluvambo	Aphrodisiac (2), Erectile dysfunction (2)	B, Rt	Boiled, oral	Sexual impotence and erectile dysfunction [76]	2	0.08	0.15	100
Tithonia diversifolia Hemsl. (Asteraceae) EAO2016/085	Amaua amalulu	Malaria (1), Tonsils (2), jiggers (1)	L	Boiled, oral/ topical	Malaria [85]	3	0.12	0.15	67
Toddalia asiatica (L.) Lam. (Rutaceae) EAO2016/086	Oluavari	Stomach aches (1), Regularizes menses (1), throat infections (1)	Rt, L, S	Boiled, oral	Stomach problems, malaria, chest pain, and sore throat [25]	3	0.12	0.12	33
Triumfetta rhomboidea Jacq. (Tiliaceae) EAO2016/087	Omkutsa-mutsatsa	Reduce blood flow after birth (1)	Rt	Crushed, oral	Expel placenta, stomach ache, and diarrhea [49]	1	0.04	0.04	100
Tristemma maritiana A. Juss (Melastomataceae) (EAO2016/088)	Ovushieni	Allergies (2)	L	Boiled, oral		2	0.08	0.08	100
Vepris nobilis Delile (Rutaceae) EAO2016/089	Indari/olutare	Stomach aches (1), joints (1)	Rt	Boiled, oral	Fever, rheumatism, skin disease, coughs, and analgesic [41]	1	0.04	0.08	100
Vernonia hymenolepis A. Rich. (Asteraceae) EAO2016/090	Oluvulosi	Stomach aches (1)	Rt	Boiled, oral	Purgative, abdominal pains, and tooth aches [86]	1	0.04	0.04	100
Vernonia adoensis Sch. Bip. ex Walp. Var. (Asteraceae) EAO2016/091	Imbulusi/ lusutsa	Eye infections (3)	L, B, Rt	Boiled, oral	Gonorrhea, malaria [87]	3	0.12	0.12	100
Vernonia aur iculifera Hiern. (Asteraceae) EAO2016/092	Lisavakhwa	Snake bites (6)	L	Crushed, topical	Blood clotting, wound healing, and measles [37]	6	0.23	0.23	100
Warbugia ugandensis Sprague (Canellaceae) EAO2016/093	Apaki	Stomach ache (1), fever (2), malaria (1)	B, Rt	Boiled/chewed, oral	Measles [88]	2	0.08	0.15	100
Indigofera arrecta Thunb. (Fabaceae) EAO2016/094	Nyalanda/ lweyu	Asthma (1), diarrhea (1)	L, B	Boiled, oral	Joints, anthelmintic, and stomach ache [41]	1	0.04	0.08	100

L = leaves, S = stems, WP = whole plant, B = bark, Rt = root, FC = frequency of citation, RFC = relative frequency of citation, UV= user value, FL = fidelity level.

advantage. Other preparation methods encountered were burning and licking of the powdered plants. Most (80%) of the herbal remedies were orally administered, 18% were used topically, while 2% were inhaled. The oral route is often preferred as most plants are used to treat digestive or peptic, respiratory, or vector-borne ailments' [2,25].

Some local plant names were based on plants' morphological characteristics. For example, *Kalanchoe densiflora* is called "okwamatsi" meaning "the watery plant" due to its succulent nature. The local names of six plants could not be established despite them being used as medicinal plants. This may imply that those plants are not indigenous to the luhya community Mukungu et al. [20].

Nearly 73% of the plants reported in this study were similar to those previously reported in studies conducted in western Kenya [1,2,9,20]. The ethnomedicinal uses reported were also consistent with other ethnobotanical reports worldwide. For example, *Ageratun conyozoides* L. and *Bridelia micrantha* Baill. were reported to be used to treat stomach aches and this was consistent with the ethnomedicinal use in Senegal [26,27]. Similarly, *Alternanthera sessile* L. and *Phyllanthus fischeri* Pax were reported to be useful in the treatment of skin diseases during this study and these findings concur with those from similar studies in Kenya and Bangladesh [1,28].

Several of the 94 plants reported during this study have already been tested in the laboratory for phytochemical, *in vitro* and/or *in vivo* pharmacological activities in a bid to validate their activity. For example, *Caelsalpinia volkensii* Harms, *Cucumis figarei* Naud., and *Conyza sumatrensis* (Retz.) E. H. Walker were reported to be useful in the treatment of malaria in this study and have been proven to possess good anti-plasmodial activity [29–31].

Quantitative analysis and the significance of the FC, UV, and FL values

The RFC of the reported medicinal plants ranged between 0.04 and 0.6. *Plectranthus barbatus* Andrews (RFC of 0.6) was the most recognized plant in the region.

The UV) ranged between 0.04 and 0.54 with *Pogonomyrmex barbatus* Andrews (0.54), *Markhamia lutea* (Benth.) K. Schum. (0.54), *Aloe* sp. (0.46), *C. sumatrensis* (Retz.) E. H. Walker (0.42), and *Flueggea virosa* Voigt. (0.39) are the most utilized plants. This may be due to their ease of availability within the area and their potency to treat common illnesses that affect the local community. Forty species had UV below 0.1, 46 species had UV between 0.1 and 0.29, while eight species had UV above 0.3. The popularity (UV > 0.35) of certain species in traditional medicine among this community may indicate an abundance of knowledge on the medicinal uses of these plants. The low UV for some of the plants may not necessarily imply they are not useful as this may be due to the scarcity of the plant species or the gradual loss of traditional knowledge about them [18].

The FL value was used to assess the potential of these plants to treat a particular health condition. The FL value ranged between 33 and 100 and categorized to different classes. The first class with range between 1 and 49 includes *C. volkensii* Harms (FL = 33), *Toddalia asiatica* L. (FL = 33), and *Rhus vulgaris* Meikle (FL = 40) which had the lowest fidelity level values against treatment of malaria, throat infection, and coughs, respectively, and then the second class with FL ranges between 50 and 74 that include 22 species. Finally, the third class with the highest FL exceeding 75 had 69 species. High FL levels for these species indicated their outstanding preference to treat a major ailment. Such information may indicate the efficacy of these plants and their likelihood to be biologically active, thus may guide the chemical and pharmacological evaluation of the reported activity against various diseases. For example, *Spathodea campanulata* Beauv., *Crotolaria pallida* Aiton. Hort., and *Dichrocephala integrifolia* (L.f.) O. Kuntze with FL = 100 may be good for treating oral infections. *Curcumis figare*i with FL = 100 can be used to treat malaria.

Pogonomyrmex barbatus Andrews was reported to remedy chest problems and skin diseases and has been proven to possess antimicrobial and antioxidant activities [32,33]. The popularity and the diverse medicinal uses of *P. barbatus* Andrews as reported in this study may be due to the presence of bioactives with a wide range of pharmacological activities such as forskolin—a labdane diterpenoid that occurs in *P. barbatus* Andrews. It was proposed that forskolin directly activates adenyl cyclase and thus the modulation of cAMP could underlie the diversity of different traditional uses of forskolin-containing species of *Plectranthus* [34]. *Micrococcus. lutea* (Benth) K. Schum. was mainly reported to treat malaria and it has antiplasmodial activity [35]. *Ricinus communi*s L. was used to induce labor and for birth control. Ricinoleic acid present in *R. communi*s L. has been shown to induce labor as it activates EP3 prostanoid receptors on intestinal and uterine smooth muscle cells [36]. *Vernonia auriculifera* Hiern.was reported to treat snakebites and is widely distributed in Kenya. Other ethnomedicinal studies report that it is useful

for blood clotting and wound healing. The plant has been validated to have antimicrobial activity [37].

This study documented for the first time 25 plant species which had not been reported in the previous ethnobotanical studies from Kakamega County and its environs (Table 2). This may be due to the fact that Kakamega County is a large area and some areas may not have been covered in previous studies. Though these 25 plants are used for medicinal purposes in other parts of Kenya, the rest of the world they have been reported to have different medicinal applications from those reported during this study. For instance, *Asparagus setaceus* Willd., *Chenopodium opulifolium* DC., and *Kalanchoe densiflora* Rolfe reportedly used to treat toothaches, diarrhea, and maintain general well-being, respectively, are used to treat skin infections in central Kenya by the Kikuyu community. *Vernonia adoensis* Sch.Bip. ex Walp. var. was reportedly used to treat eye infections and also used to remedy malaria in rift valley region by the Kalenjin community. The plant use among Kenyan communities is largely based on the flora available in the local regions and that similar plant use among different communities may be due to some plants having a wider geographical distribution or from the interchange of knowledge within communities [20].

Use of mainstream medicine

Some of the herbal preparations were used alongside the conventional medicines. Six participants noted that some of their patients had previously used or are currently using conventional medicines. The existence of diseases which no cure exists has favorably contributed toward the use of herbal medicines in the study area. For example, *F. virosa* Voigt that has anti-HIV activity [38] was used in the management

Table 2. Medicinal plants reported the first time in Kakamega County and their uses worldwide.

Plant	Community and area	Reported ethnomedicinal use
Alternanthera sessilis L.	India	Neuritis, eye diseases [89]
Asparagus setaceus Willd.	Kikuyu (Central Kenya)	Boils [90]
Carisa spinarum L.	India	Microbial and liver disease [91]
Chenopodium opulifolium DC.	Uganda, Kikuyu (Central Kenya)	Malaria [49] wounds [91]
Crotalaria anagyroides Kunth.		Human and veterinary medicine [92]
Crotolaria pallida Aiton. Hort.	India	Microbial infections [93]
Cyphostemma ukerewense (Gilg) Desc.	Zaire	Child birth [94]
Dichrocephala integrifolia (L.f.) O. Kuntze	Tanzania	Diarrhea [95]
Hibiscus fuscus Garcke	Uganda, Tanzania	Muscle pull [49], Chronic diarrhea [96]
Kalanchoe densiflora Rolfe	Kikuyu (central Kenya), Keiyo district (Kenya)	Swelling on skin [90], wounds [67]
Maytenus arbutifolia var. *sidamoensis*	Ethiopia	Cattle feed [97]
Physalis minima L.	Uganda	Coughs [35]
Physalis peruviana L.	China	Anticancer [98]
Rubia cordifolia L.	India	Blood purifier [99]
Rumex abyssinicus Jacq	Uganda	Sexual impotence, erectile dysfunction [76]
Sida cordifolia L.	India	Pain, nervous disorders [41]
Sida tenuicarpa Vollesen	Uganda	Sexual impotence, erectile dysfunction [76]
Solanecio cydonifolius (O. Hoffm.) C. Jeffrey	Uganda	Witchcraft [100]
Solanum dasyphylum Schumach.	Ethiopia	Trypanosomiasis, cough [81]
Tarenna graveolens (S. Moore) Bremek	Tanzania	Cryptococcal meningitis [96]
Vepris nobilis Delile	Kenya	Fever, rheumatism, skin disease, coughs, analgesic [41]
Vernonia hymenolepis A. Rich	Trans nzoia (Kenya)	Toothache [86]
Vernonia adoensis Sch. Bip. ex Walp. Var.	Rift valley (Kenya)	Gonorrhea, malaria [7]
Vernonia auriculifera Hiern.	Uganda	Placenta removal [49]
Tristemma maritiana A. Juss.	Uganda	Meat allergies [101]

of HIV/AIDS and was reported to minimize side effects of conventional therapies such as diarrhea by one of the participant. Similar to the findings from Suba District, Kenya, some patients that had been diagnosed with chronic diseases such as HIV/AIDS and diabetes from mainstream health centers opted to combine both herbal and conventional medicines with the belief of a synergistic effect [39].

Economic, social, and cultural attitudes toward traditional medicine

The participants' economic, social, and cultural attitudes had an effect on their traditional medicine practices. For instance, all the TMPs reported traditional medicine as being a source of income. Though no standard treatment fee was set, patients were expected to give a small amount of money after treatment. However, the financial gains from this practice are not that lucrative; thus, the TMPs still engage in other economic activities such as farming. The fact that fewer TMPs were located in urban centers as compared with those in rural areas could indicate a negative attitude whereby the urban population considers herbalism as an outdated practice. Culturally, women of childbearing age are not allowed to practice herbalism as it is believed that could lead to a curse and infertility. The youngest female participant in this study was 48 years old. Also, it is believed that seeking conventional treatments for some ailments such as "ebihoho" attributed to sorcery and is usually described as high fever and vomiting in children leads to the death of the patient. *Ageratum conyzoides* Linn. was found to be useful in cultural events such as circumcision to stop excessive bleeding and quicken the healing process.

Comparison of traditional knowledge among traditional medicine practitioners (TMPs)

Well-known TMPs were identified with the help of local leaders (village elders and chiefs) and also villagers that had formerly sought herbal treatment before so as to ease the identification of "genuine'' TMPs. These TMPs were easily able to recognize important signs and symptoms of various illnesses that affect the community. The TMPs displayed diversity in their use and preparation of medicinal plants. For instance, some TMPs reported similar uses for the same plant as is the case with *P. barbatus* Andrews whereby six TMPs reported using the plant in the management of skin diseases, while other plants such as *C. volkensii* Harms reportedly had a different use by each of the three TMPs that utilized it. This lack of consensus may indicate that there is a little or no sharing of information among the TMPs. Despite their varied levels of education, all healers had an almost similar level of knowledge on medicinal plants with the least number of plants being identified by one participant being five. Seemingly, the age difference played a role in the participants traditional knowledge as the elderly participants (60 years and above) provided more information (based on number of plants and diseases treated) on medicinal plants use than the participants below 60 years. This may be due to the experience they have acquired over the years in their practice. All participants reported having received patients of all genders though one female participant noted she mainly specializes in female-related issues such as family planning, menstrual pain, and childbirth, while one male specialized in treating male-related complaints such as erectile dysfunction.

Conclusion

This study has identified 94 medicinal plants used in Kakamega County that may be potential sources of new therapeutic agents. Hopefully, this information will stimulate further scientific research into their reported traditional uses and bioactivity in order to give credence to their traditional use and increase public confidence in complementary and alternative medicine. The youngest study participant was 35 years old. It seems that young people are not interested in traditional medicine and this highlights a need to sensitize the youth within this region on traditional knowledge in order to preserve this information. Also, the information on low UV may help guide medicinal plant conservation efforts within Kakamega County.

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Ethics approval and prior informed consent

Ethical approval for this study was obtained from Kenyatta National Hospital-University of Nairobi Research Ethics Review Committee (Reference number: P38/1/2016). Prior to conducting the interviews, the objectives of the study were well explained to the study participants and written consent obtained.

Authors' contributions

Elizabeth Odongo, Nelly Mungai, Peggoty Mutai, Esther Karumi, and Julius Mwangi were involved in designing of the study. Elizabeth Odongo and Joseph Omale collected field data. All authors were involved in the analysis of data. The first draft was done by Elizabeth Odongo and all authors were involved in the revision of the draft manuscript and agreed to the final content.

Conflict of interest

The authors declare that they have no conflict of interest.

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